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ABSTRACT

Perceptual-motor functioning is a cyclic process involving: (1) organizing incoming sensory stimuli with past or stored perceptual information; (2) making motor (internal) decisions based on the combination of sensory (present) and perceptual (past) information; (3) executing the actual movement (observable act) itself; and (4) evaluating the act or movement performance, which in turn feeds back information (reafference) into the sensory-perceptual aspects of the process, thus beginning the cycle over again. This paper discusses perceptual aspects of motor performance and relevant visual factors during infancy and childhood that may influence perceptual-motor functioning. The infant's perceptual development, in the areas of: fixation; tracking; color discrimination and preference; form, shape, and pattern discrimination; visual acuity; and depth perception, is described. Visual acuity, figure-ground perception, depth perception, visual-motor coordination, and perception of movement skills and abilities of children are also discussed, as well as the role movement has as a facilitator of perceptual development. It is concluded that incomplete visual development may make performance requirements of many youth physical activities beyond the child's present level of perceptual sophistication. Four recommendations are made for planning motor development activities that suit the individual child's level of perceptual development. (CJ).

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PERCEPTUAL ASPECTS OF MOTOR PERFORMANCE*

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Perception has been defined as "any process by which we gain immediate awareness of what is happening outside ourselves" (Bower, 1973, P. 1). Perception is the means by which we interpret the sensory information made available to us from each of our various sensory modalities. On the other hand, the word "motor" is generally understood to refer to those "underlying biological and mechanical factors that influence movement" (Gallahue, 1982, P. 15). Motor processes are internal processes that manifest themself through the observable act of movement. The combination of the words "perceptual" and "motor" to form the term "perceptual-motor" came into vogue during the 1960's and has been used to imply a complex interaction among perceptual motor, and cognitive processes. Depending upon ones orientation, the term may be viewed from either a cognitive perspective or from a psychomotor perspective.

When viewed from a cognitive perspective we see the prevading influence of the theoretical positions of D. O. Hebb (Hebb, 1949) and Jean Piaget (Piaget, 1952). Hebbian theory suggests that practice in a variety of perceptual-motor tasks will aid in central nervous system organization and thus facilitate intellectual development. Piagetian theory also lends support to the cognitive perspective through its emphasis on the Sensorimotor Phase of development (Piaget, 1952) as an important facilitator of cognitive functioning. The theoretical frameworks of both Hebb and Piaget suggest a link between perceptual-motor activities, perception, and cognition, and are largely responsible for the perceptual-motor "bandwagon" on to which many of us jumped during the 1960's and the early 1970's. However, to date, the vast majority of controlled studies have lent only minimal support to the general notion of a perceptual-motor basis for more sophisticated perceptual and cognitive functioning (Chissom, Thomas, and Biasiotto, 1972; Thomas and Chissom, 1972, 1973, and 1974).

It seems all together fitting that the focus of this paper centers on the "Perceptual Aspects of Motor Performance" rather than reviewing the purported cognitive link between perception and movement. The term "perceptual-motor" as used here is viewed from a psychomotor perspective and refers to the organization and integration of current sensory information with past perceptual information in an attempt to perform a controlled gross motor movement. When viewed in this manner it is plain to see that perceptual-motor functioning is a cyclic process (see Figure 1) involving:

1. Organizing incoming sensory stimuli with past or stored perceptual information.
2. Making motor (internal) decisions based on the combination of sensory (present) and perceptual (past) information.
3. Executing the actual movement (observable act) itself.
4. Evaluating the act or movement performance which in turn feeds back information (reafference) into the sensory-perceptual aspects of the process, thus beginning the cycle over again.

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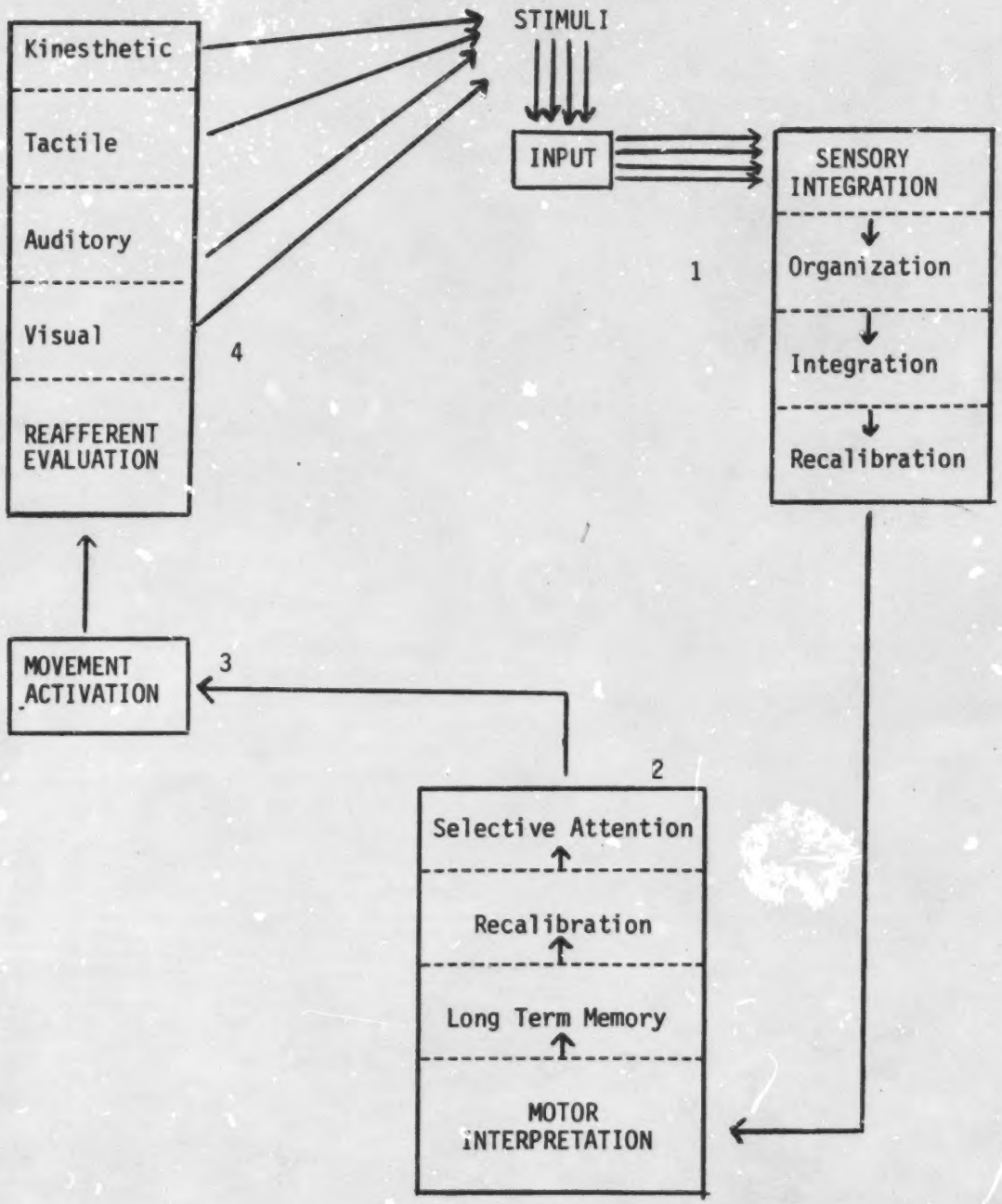

FIGURE 1: THE PERCEPTUAL-MOTOR PROCESS

Our discussion of the perceptual aspects of motor performance is delimited to those relevant visual factors during infancy and childhood that may have an influence on the perceptual-motor functioning of the individual. Visual perception as defined here is the ability to: attend, attach meaning, interpret, and retain relevant visual stimuli.

VISUAL PERCEPTUAL DEVELOPMENT IN INFANCY

The newborn receives an abundance of sensory stimulation through the various sense modalities. Responses are made to these stimuli, but they have limited utility and are more or less automatic. The newborn is unable to fully integrate sensory impressions in order for meaning to be attached to these sensations. It is only when sensory stimuli can be integrated with stored information that these sensations take on meaning for the infant and warrant being called "perceptions". For example, light rays impinging upon the eye register on the retina and are transmitted to appropriate nerve centers in the sensory area of the cortex. The newborn's reaction is simple (sensation); if the light is dim the pupils dilate. If the light is bright the pupils constrict and some of the stimulation is shut off (consensual pupillary reflex). Soon the infant blinks as the stimulus approaches these simple reflex actions persist throughout life, but soon the infant begins to attach meaning to the visual stimuli received. A certain face becomes "mother". A blob is identifed as a triangle or as a square. The infant now attends to certain stimuli and begins to apply basic meaning to them. The powers of visual perception are now developing at a rapid rate to a more sophisticated level.

At birth, the neonate's eyes have all the parts necessary for sight and are completely formed with the exception of the fovea, which is incompletely developed. The ocular muscles are also immature. These two factors result in poor fixation, focusing, and coordination of eye movements. The blinking and lacrimal apparatuses are poorly developed at birth, and the neonate is unable to shed tears until one to seven weeks after birth. It is debatable whether the newborn possesses color vision due to the limited amount of rhodopsin (visual purple) present in the rods and cones of the eye. Fixation, tracking, visual acuity, color preference, depth perception, and visual discrimination develop rapidly during the early weeks and months of life. Table I depicts the major developmental aspects of infant visual perception along with the approximate ages at which they begin to emerge.

VISUAL PERCEPTUAL DEVELOPMENT IN CHILDHOOD

The fact that performance of most gross motor skills involves an element of visual perception is apparent to most. Vision is undoubtedly the most used of our sensory modalities and the one on which we have come to base the majority of our perceptions. Although recent advances have been made with devices such as "beeper balls" for use by the blind in softball, golf, and even badminton, it is difficult for most of us to conceive of being deprived of our visual sense and being required to perform gross motor movement task with accuracy and control. However, children by the very developmental nature of their visual perceptual abilities are often asked to perform sport skill tasks that require sophisticated refinement of a variety of visual perceptual abilities before they are developmentally ready.

TABLE I: SELECTED DEVELOPMENTAL ASPECTS OF INFANT VISUAL PERCEPTION

VISUAL QUALITY	SELECTED ABILITIES	APPROXIMATE AGE OF ONSET
FIXATION (Zubek, 1954; Bower, 1966; Jeffrey, 1966) Fixation is probably monocular and essentially reflexive during the first six weeks of life.	Fixates one eye on bright objects	Birth
	Fixates both eyes on bright objects	2 to 3 days
	Turns head from one stationary bright surface to another	11 days
	Follows an object in motion, keeping the head stationary	23 days
	Directs eyes toward an object	10 weeks
TRACKING (Pratt, 1954; Haith, 1966; Field, 1976) Tracking forms the basis for later crucial avoidance and approach reactions, and develops far sooner than the motor component.	Horizontal Vertical Diagonal Circular	Begins at Birth. Time of onset is inconsistent, but the sequence is fixed.
COLOR DISCRIMINATION AND PREFERENCE (Spears, 1964) Inconsistent evidence. Color vision may or may not be present at birth depending on the amount of rhodopsin.	Color Vision	Birth?
	Color Preference	4 months
	Prefers shape to color	15 days
	Reacts to color	4 months
FORM, SHAPE, AND PATTERN DISCRIMINATION (Fantz, 1963; Hershenson, 1964; Lewis et al., 1966; Bower, 1977) Discrimination begins early and develops rapidly in complexity. The human face is the favorite of all objects	Prefers patterned objects to plain	Neonate
	Imitates facial gestures	Neonate
	Prefers human face to all other objects	Neonate
	Size and shape constancy	2 months
	Discriminates between two and three-dimensional figures	3 months
	Geometric shape discrimination	6 months
VISUAL ACUITY (McCandless, 1967) The length of focus increases daily as the eye matures.	Organically complete visual apparatus	Birth
	Length of focus 4 to 10 in.	Birth to 1 week
	Length of focus about 36 in.	3 months
	Length of focus about 100 ft.	1 year
DEPTH PERCEPTION (Gibson, 1960; Bower, 1966; Fanta & Fagan, 1975; Van Hofsten, 1977; Wall, 1978)	Monocular vision	Birth
	Binocular vision	2 months
	Depth perception	2-6 months

By age two the occular apparatus is mature. The eyeball is nearly adult in terms of size and weight. Each of the anatomical and physiological aspects of the eye are complete, but perceptual functioning has not been mastered. The period of childhood, especially from ages three through nine have been shown to be very important in the development of the individual's visual perceptual abilities (Frostig et al., 1966; Williams, 1983). The child's visual acuity, figure-ground perception, depth perception, visual-motor coordination and perception of movement, should be of particular interest to motor developmentalists, biomechanists, physical educators, and youth sport leaders. What we know about the developmental aspects of each of these elements of visual perception are depicted in Table II, along with the approximate age at which they appear to emerge. Each of these perceptual qualities are important because of the numerous implications that they have for successful execution of the many movement activities sport skills characteristic of our society.

Visual Acuity

Visual acuity may be defined as the ability to distinguish detail in either a static or dynamic settng. Static visual acuity involves detecting detail in non-moving objects. Dynamic visual acuity refers to the ability to pick out detail in moving objects (Whiting, 1974). Static visual acuity according to Williams (1983) has been shown to improve in sports with age. The periods between 5 and 7, and 9 and 10 appear to be the peak periods for improvement with little change in static visual acuity after age 10 (Brug and Hulbert, 1961). Dynamic visual acuity tends to follow the same pattern, but with improvement continuing until about 12 years of age. Boys appear to be superior to girls in terms of both static and dynamic visual acuity at all ages (Cratty, 1973).

Figure-Ground Perception

Visual figure-ground perception may be defined as the ability to visually separate an object (figure) from its surrounding (background). Lowe (1973) indicated that developmentally the process of figure-ground perception is one in which the child progresses from focusing on the whole to being able to focus on the relevant parts of the visual field. Utilizing kindergarteners as subjects, Gallahue (1968) found that performance scores on a simple novel locomotor task requiring visual figure-ground discrimination were significantly disrupted as the object of regard was manipulated to blend more with the background, and as the background itself became more distracting.

Based on the figure-ground subtest of the Frostig Developmental Test of Visual Perception (1966) Williams (1983) indicated that children have been shown to demonstrate yearly age improvements in their visual figure-ground perception. Girls were shown to improve at a steady rate from 5 to 8 years of age while boys improved rapidly until about age 7, whereupon both groups tended to level off and exhibit few age related changes.

Depth Perception

Depth perception is closely associated with visual figure-ground perception.

TABLE II: SELECTED DEVELOPMENTAL ASPECTS OF CHILDREN'S VISUAL PERCEPTION

VISUAL QUALITY	SELECTED ABILITIES	APPROXIMATE AGE
VISUAL ACUITY	Rapid Improvement	5-7
Ability to distinguish	Plateau	7-8
detail in static and	Rapid Improvement	9-10
dynamic settings	Mature (Static)	10-11
(Burg & Hullert, 1961;	Plateau (Dynamic)	
Cratty, 1973; Whiting, 1974)	Mature (Dynamic)	11-12
FIGURE-GROUND PERCEPTION	Slow Improvement	3-4
Ability to separate an	Rapid Improvement	4-5
object from its surroundings	Slow Improvement	6-7
(Frostig, 1966; Gallahue,	Slight Spurt	7-8
1968; Lowe, 1973; Williams,	Mature	8-10
1983)		
DEPTH PERCEPTION	Frequent Judgement Errors	3-4
Ability to judge distance	Few Judgement Errors	5-6
relative to oneself	Rapid Improvement	7-11
(Gibson, 1950; Harway, 1963;	Mature	by age 12
Johoda and McGurk, 1974;		
Yonas et al., 1978;		
Williams, 1983)		
VISUAL-MOTOR COORDINATION	Rapid Improvement	3-7
Ability to integrate	Slow, Slight Improvement	7-9
use of eyes and hands	Mature	9-10
(Williams, 1977; Payne,		
1981)		
PERCEPTION OF MOVEMENT	Overestimates Speed	3-5
Ability to detect, make	Accurate Comparisons	5-7
judgements and track a	Mature Judgements	8-12
moving object		
(Wapner and Werner, 1957;		
Williams, 1983)		

It may be defined as the ability to judge the distance to or from an object in terms of one's positional orientation. One's perception of depth is influenced by numerous stimulus variables including texture, spacing, and luminance (Gibson, 1950). Binocularity has been shown to improve throughout early childhood, but according to Johoda and McGuirk, (1974) and Yonas and associates (1978) four year olds often fail to detect differences in two and three dimensional slides. However, five and six year olds were shown to almost never make such errors in depth judgments. Williams (1983) indicates that 12 year old boys are as accurate in their depth judgments as are older adult males. Both Gilinsky (1960) and Harway (1968) found that ability increased with age in being able to judge apparent depth in children and that the performance of 12 year olds was similar to that of adults. Based on the limited information available on depth perception in children we may speculate that perception of depth begins developing early in life and is mature by age 12.

Visual-Motor Coordination

Visual-motor coordination may be defined as the ability to integrate use of the hands and eyes in a harmonious manner. Williams and her associates (1977) found linear improvements in groups of children from five to ten years of age with only minimal gender differences observed. Payne (1981) demonstrated that increased ball size was an important factor in successful completion of a ball catching task with first grade children a fact that may be related, in part, to reductions in the necessity for coordinated visual-motor performance as ball size increases. Other factors such as increased ease in figure-ground perception, and object tracking may also contribute to improved performance scores with first graders as ball size increases.

Perception of Movement

Perception of movement may be defined as the ability to detect, make judgments, and track a moving object. It is often considered to be the most primitive of all visual perceptions (Kidd, and Reviore, 1966). Even so, the research information available in this area is unorganized, cross-sectional, and scattered about the literature. Far less research has been done in this area than into the other areas of visual perception. However, Williams (1983) noted that children in the early elementary years do not have the refined ability to judge moving objects in space, and that accurate perception of objects in motion improves to about 12 years of age. Fraisse and Vautrey (1952) found that five year olds were capable of comparing the speeds of two moving objects. Furthermore, Wapner and Werner (1957) found that differences in children's ability to judge the relative speed improved with age, and that younger children tend to overestimate the speed of an apparently moving object.

MOVEMENT AS A FACILITATOR OF PERCEPTUAL DEVELOPMENT

Thus far, our discussion has centered on the developmental nature of perception in the motor performance in children, but what about the converse? That is, what role does movement play as a facilitator of perceptual development?

Held and his colleagues (1961, 1963, 1964, 1967), Smith and Smith (1966), and Riesen and Aarons (1959) all speculated as to the importance of movement in the development and refinement of visual perceptual abilities.

Each conducted investigations based on the hypothesis that self-produced movement is a necessary as well as a sufficient condition for visual-motor adjustment to occur within a visually altered environment. They contended that without movement, visual perceptual adjustments will not occur, and that the muscles and the motor aspect of the nervous system are intimately involved with perception, with one being dependent upon the other. The concept of a relationship between movement activity and perceptual development has also been indirectly supported by a decline in performance scores on perceptual and motor deprivation experiments (Hebb, 1949; Riesen and Aarons, 1959), and experiments testing visual perceptual adjustment to an optically rearranged environment (Held and Blossom, 1961; Held and Mikaelian, 1964; Hoepner, 1967; Gallahue, 1982).

The fact remains, however, that the results of each of these experiments are only speculative when applied to the role of movement in the development of perceptual abilities in children. At this juncture, we still do not know the extent of the role that movement plays in perceptual development, nor the complete role of the influence of perception on motor performance. However, it is probably safe to say that movement is a sufficient condition for encouraging the development of certain visual perceptual abilities. Whether it is, in fact, a necessary condition is doubtful, but this conclusion must away further experimentation.

SUMMARY AND IMPLICATIONS

Due to the incomplete development of certain aspects of the child's visual world the performance requirements of many youth sport activities may be experientially and/or developmentally beyond his or her present level of perceptual sophistication. It is becoming increasingly clear that the visual world of children is not the same as that of older youth or adults. Their visual world is in the formative stages and thus developmentally limited. Therefore, we need to be certain that involvement in youth sport activity by young children is done with full recognition of, and appropriate modifications for, the limitations that children have in terms of their perceptual sophistication.

The fact that the perceptual sophistication of the individual is intricately related to his or her success in the performance of most gross motor tasks makes it necessary for us to:

1. Make appropriate adjustments in the skill requirements.
2. Make appropriate modifications in rules and equipment.
3. Adjust our level of expectation to the perceptual as well as the physical maturity of the individual.
4. Recognize that the mechanics of movement are influenced by the level of perception required for successful performance.

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